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Technology Opportunity

Technology Transfer & Partnership Office

TOP3-00168

High-Performance Silicon Carbide (SiC) Matrices

Technology

GRC has developed process methods within its Ultra Efficient Engine Technology Project that remove production-related defects from the matrix material of SiC/SiC composites that are fabricated using conventional matrix infiltration approaches, such as chemical vapor infiltration.

Benefits

When applied to state-of-the-art SiC/BN/SiC composite structures, these methods have been demonstrated to significantly improve

- Composite thermal conductivity
- Creep resistance
- Strength retention at high temperatures

Commercial Applications

SiC/SiC composites are often used in high-temperature structural aerospace, industrial, and military applications such as

- Engine hot-section components
- Heat exchangers
- Furnace components

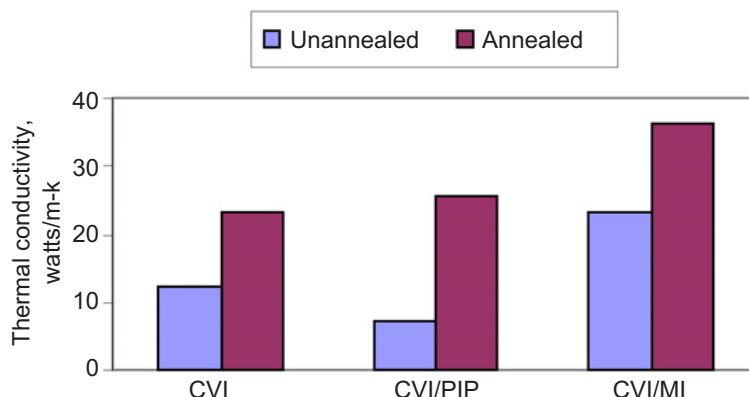


Figure 1. — Effect of GRC annealing process on the room-temperature through-the-thickness thermal conductivity for Sylramic iBN SiC/BN/SiC composite panels containing full chemical vapor infiltration (CVI) (~50 vol%) SiC matrix, CVI (~35 vol%) plus PIP SiC matrix, and CVI (~35 vol%) plus melt infiltration (MI) SiC matrix.

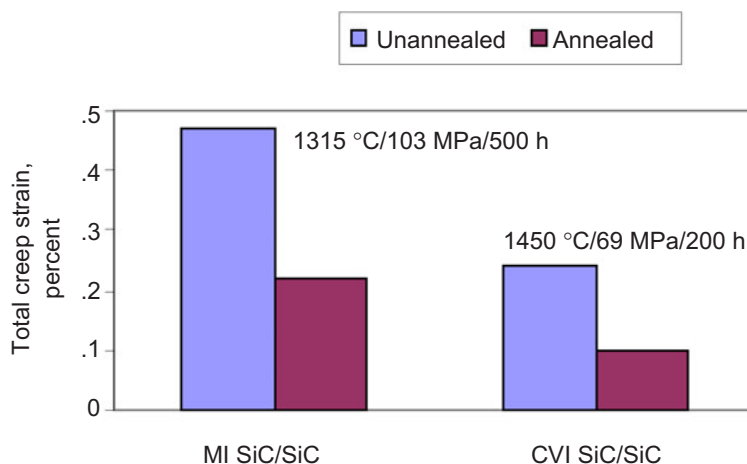


Figure 2. — Effect of GRC annealing process on the tensile creep strain for Sylramic-iBN SiC/BN/SiC composite panels with a CVI (~35 vol%) plus MI SiC matrix and with a full CVI (~50 vol%) SiC matrix.

Technology Description

This technology uses specially designed treatments at temperatures above 1600 °C to anneal out structural defects in SiC matrices formed by conventional low-temperature processing approaches. This technology has been demonstrated to be particularly beneficial for removing excess silicon and production-related defects from those SiC matrices formed by chemical vapor infiltration. If the composite material includes fibers and fiber coatings that are functionally stable under the thermal treatment conditions, this technology can be applied to a variety of as-fabricated, high-performance, high-temperature composite systems with SiC matrices. Results have shown that this treatment significantly improves the thermal conductivity, creep resistance, and strength retention of high-performance SiC/SiC composites with minimal degradation in their ultimate tensile strength.

GRC researchers have applied this annealing technology to SiC/BN/SiC panels, and observed the thermal conductivity and creep benefits shown in figures 1 and 2, respectively. These panels were fabricated with GRC-developed Sylramic-iBN SiC fibers [ref. 1] and with BN fiber coatings and SiC matrices produced by CVI at GE Power Systems Composites. For these panels, total fiber and coating volume fractions were ~35 and 5 percent, respectively, and the CVI SiC matrices were deposited at ~50 percent (full CVI) and ~35 percent volume fractions. Remaining open porosity in the 35 percent CVI SiC matrices were filled either by repeated polymer infiltration and pyrolysis (PIP) of an SiC yielding polymer, or by the MI of silicon near 1400 °C. Figure 1 conductivity results show the detrimental effect of trapped porosity in the full CVI SiC matrix and the beneficial effect of enhanced pore filling for the hybrid CVI plus MI SiC matrix. However, as shown in figure 2, the full CVI SiC matrix after the NASA process is best in creep resistance and allows temperature capability beyond 1400 °C, which is near the upper use temperature for the CVI plus MI SiC matrix [ref. 2].

Options for Commercialization

There is a patent application in process for this technology. NASA is seeking companies interested in applying this technology to commercial applications.

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References

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2. Bhatt, R.T., and DiCarlo, J.A.: Thermal Stability of Melt Infiltrated SiC/SiC Composites, Ceramic Engineering & Science Proceedings, 2003, in press.

LEW-17595-1

Key Words

Silicon carbide matrices
Thermal conductivity
Creep resistance
High-temperature composites